YELLOW-WHITE PINE FORMATION AT LITTLE MANISTEE, MICHIGAN

LeRoy H. Harvey

(WITH SIX FIGURES)

In a previous paper the writer[1] presented the inadequacy of current phytogeographical classification of the northern half of the Southern Peninsula of Michigan, and at that time advanced a scheme consonant with observational and experimental data. This region was shown to lie within that phytogeographical area whose climax (eschatophytic) forest type is of the maple-beech or mixed hardwood formation. It was shown that within this great transitional area there were at least two edaphic climax formation-complexes, the yellow-white pine and the black-white oak.

This paper is limited to a consideration of certain aspects of the "Big Pines" formation as it is exhibited at Little Manistee in Lake County, Michigan. The formation is now limited to two isolated stands one and one-half miles apart in the valley of the Little Manistee River which traverses each stand, the formation occupying its terraces and at a few points extending up on to the contiguous glacial highlands. These two stands are but the remnants of a once magnificent forest which occupied this general region. They are known locally as the Upper Pines and Lower Pines, and contain respectively about 160 and 60 acres. A general idea of these stands may be obtained from figs. 1–4.

During the preparation of this paper it was learned that the Upper Pines had suffered the inevitable, and that the saw and ax were rapidly resolving it into a historical fact. In light of this it has seemed wise to present rather fully all data available as a matter of record. Through the personal interest and activity of Judge Harry D. Jewell, of Grand Rapids, these magnificent stands of pines in 1914 were temporarily saved from complete deforestation, the logging operations actually being in progress at

[1] Harvey, LeRoy H., Some phytogeographical observations in Lake County, Michigan. Mich. Acad. Sci. Rept. 213–217. 1919.

the time of his intervention. Steps were taken toward the formation of a company to conserve this area, and the owner, E. GORDEN FILER, agreed to contribute a substantial part of the value of the standing timber. The State Legislature of 1915 sought to encourage the preservation of such tracts of timber, and passed a bill with the amendment to this effect, as proposed by Judge

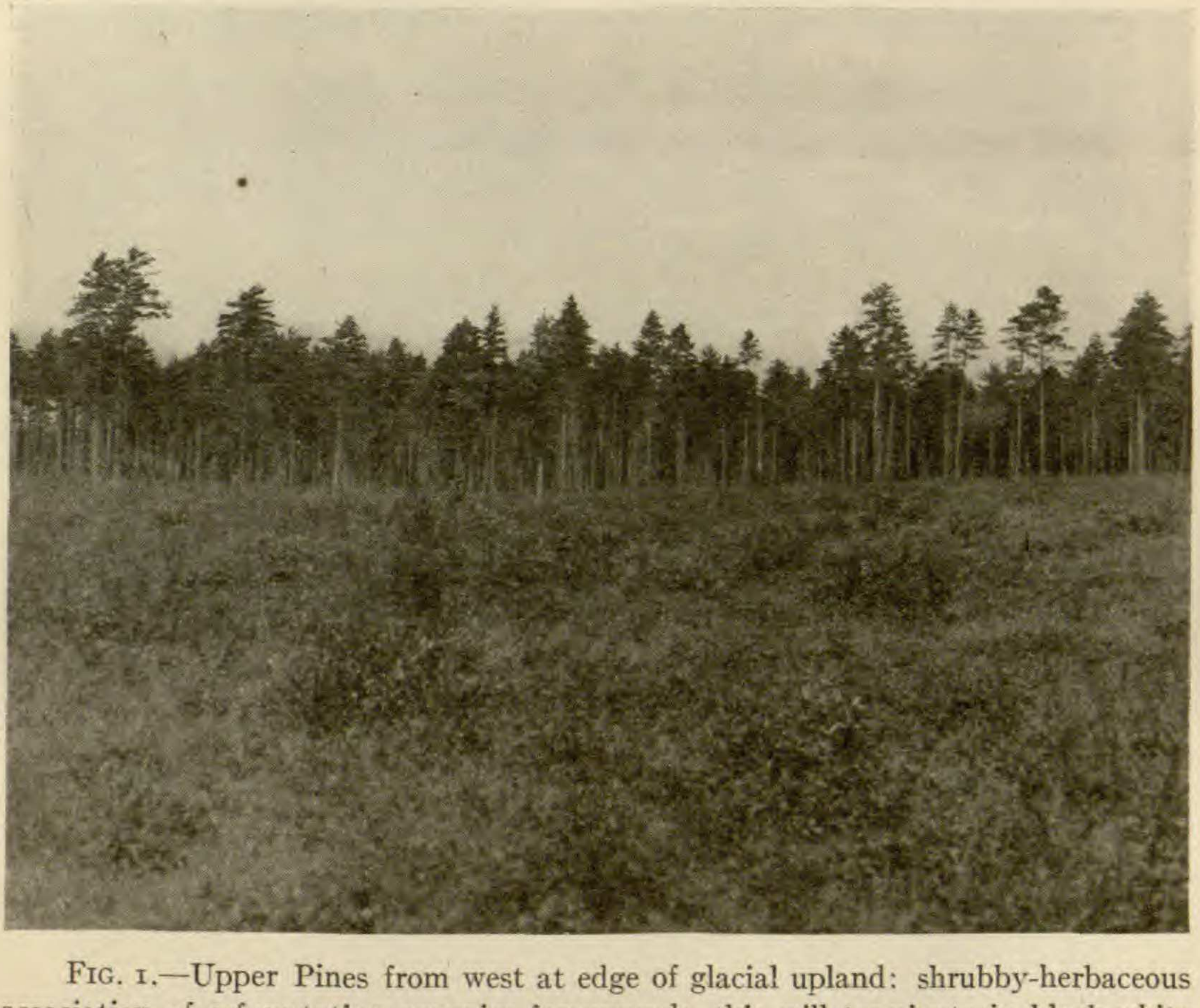

FIG. 1.—Upper Pines from west at edge of glacial upland: shrubby-herbaceous association of reforestation occupies foreground; this will terminate in black-white oak complex.

JEWELL. Unfortunately the Governor, through the mistaken advice of one of the State Tax Commissioners who did not understand the merits of the measure, misconstrued its purpose, and vetoed the bill. It was hoped that this tract would eventually be made a part of the Public Domain. Action was delayed, however, and Michigan's archaic and prodigal method of forest taxation left no alternative. The Upper Pines are gone; a crime to be laid at the door of our state officials. Nevertheless, the efforts of these public spirited men cannot be commended too highly, and should serve as a stimulus for other efforts all over the state looking toward the preservation in Public Domain of original stands of forest types and plant associations. This is not wholly a matter of nature sentiment, but one of scientific necessity.

FIG. 2.—Upper Pines, view within formation which here occupies a high terrace: dominant form of herbaceous layer is *Pteris aquilina;* atmometer station 7.

To Judge JEWELL I wish to express my deep appreciation of his hospitality during the prosecution of my field work. I also wish to express my thanks to my colleague, Dr. WILLIAM McCRACKEN, who assisted me throughout in taking data.

Climatic factors

The climatic conditions of the region in all probability are fairly revealed in the data taken at Luther (table I), less than ten miles to the southeast, at a United States Volunteer Station. It will be noted that the maximum range in temperature for the four years is 136°, from 100° in August 1918 to −36° in February 1918. The average yearly rainfall for the four years is 33.65 inches, ranging from 28.29 inches in 1917 to 39.08 in 1920. The last killing frost in spring was on June 23, 1920, and the first killing frost in autumn was on September 11, 1917. The shortest growing period was 87 days in 1917, and the longest 106 days in 1919–1920, with an average of 98 days. While means and averages convey certain pertinent facts, it is the extremes which indicate the critical points of climatic influence on vegetation.

TABLE I

CLIMATIC FACTORS 1917–1920*

Factors	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Mean maximum temperature	24.2	26.4	42.3	56.1	66.8	77.5	80.7	78.6	70.1	54.6	43.7	30.8
Mean minimum temperature	8.45	7.7	21.0	30.7	40.7	52.0	55.1	53.5	46.2	39.6	28.9	16.8
Maximum temperature.....	45	45	68	72	92	92	98	100	89	80	65	65
Minimum temperature.....	−27	−36	−18	11	22	27	33	34	27	18	6	−19
Mean precipitation	1.37	1.07	2.49	2.93	3.35	3.38	3.68	3.49	3.06	4.00	2.44	2.38
Minimum precipitation.....	1.07	0.65	1.50	2.45	2.03	2.00	1.36	2.23	2.32	3.09	1.17	1.28

* The temperature records are in Fahrenheit and the precipitation in inches.

These climatic conditions are adequate to support the maple-beech or mixed hardwood formation which are found in typical development within the region. It is apparent, therefore, that the yellow-white pine complex is the expression of a combination of edaphic factors which exclude the climax type. The main critical factor, aside from the question of post-glacial invasion and pre-occupation, is undoubtedly the wilting coefficient of the soil.

Ecological factors

The ecological factors investigated included soil moisture, evaporation, and light intensity. Records were made over a period of twenty-eight days, August 3–31, 1918. As August–September practically represents the minimum of favorable ecological conditions for the growing period, the factorial values of either month

FIG. 3.—Lower Pines, northern end of stand: white oak in left foreground; reforestation from white oak grubs and invasion of black oak.

FIG. 4.—Lower Pines: fires excluded for a number of years, and there is a well developed shrubby layer in which species of *Cornus*, *Viburnum*, *Amelanchier*, *Crataegus*, and *Prunus*, as well as saplings of red and white oak are common; seedlings and saplings of white and yellow common in open places.

will adequately serve to indicate the critical ecological conditions. It was expected that some light would be thrown by such data upon the questions of the relation of evaporation to succession and upon the classical conception of the successional development of the formations of a region. In my paper already referred to, the data seemed to show that evaporation had no causal relation to succession. It was argued that the measurements of the ecological factors of any association are more largely a result of that stage of the succession rather than the cause of it. Specifically, the evaporation is less in the Big Pines formation than in the open herbaceous association, because of the greater protection in the former from factors enhancing water loss; the Big Pines formation is the cause of lowered evaporation and not the result of it. The evaporation conditions of any pioneer association obviously represent the conditions which must be tolerated by the invaders from any higher ecological type of association. These invaders help to reduce the evaporation, and finally, as the next step in the succession is established, it comes to possess its own evaporation ratio determined by its own canopy, shrubby, and herbaceous layers.

SOIL WATER.—Soil samples were taken in two series at depths of 7.5 cm. and 25 cm. by means of a knife-blade trowel, and placed at once in friction top cans of 350 cc. capacity. The samples were collected on August 4, 11, 18, and 25. Analyses of the samples were completed within the following month. The moisture-holding capacity (MHC) was computed upon the basis of dry weight as well as upon the basis of equal volumes, according to HILGARD's[2] method. Each determination represents the average of the four samples for each station and series. The total field capacity (TFC) was computed directly upon the basis of dry weight. The wilting coefficient (WC) was calculated by the formula of BRIGGS and SHANTZ.[3] $WC = \frac{\text{moisture holding capacity} - 21}{2.90(\pm 0.021)}$, in which the MHC is determined by volume per cent. It is recognized that the WC data thus computed are only an approximation, as such data preferably should be based either upon experimental

[2] HILGARD, E. W., Soils. New York. 1906.

[3] BRIGGS, L. J., and SHANTZ, H. L., The wilting coefficient for different plants and its indirect determination. U.S. Dept. Agric., Bur. Plant Ind. Bull. 230; BOT. GAZ. 51:210–219. 1911; 53:20–37, 229–235. 1912.

determination or computed from the moisture equivalent mechanically determined. These data will be found in table II. For purpose of comparison similar data from the jack pine, black-oak, and the Kalamazoo maple-beech associations are added.

A study of these data brings out certain facts which are quite in agreement with field observations. The range in TFC in the Big Pines at 7.5 cm. from 7.1 to 14.9 per cent, with a corresponding range in WHC (column 3) from 48.5 to 52.5 per cent, is a direct expression of the effect of fires on the humus layer. At 25 cm. this effect is less apparent in the WHC, but the absence of protection from a good humus layer is shown in the TFC at the same depth.

TABLE II

SOIL WATER DETERMINATIONS IN PERCENTAGES

Station and association	TFC by DW		WHC by DW		WHC by volume		WC by formula	
	7.5 cm.	25 cm.	7.5 cm.	25 cm.	7.5 cm.	25 cm.	7.5 cm.	25 cm.
6. Upper Pines..........	14.9	6.6	44.4	28.7	53.5	41.8	11.2	7.1
7. Upper Pines..........	9.9	5.3	43.4	38.2	52.3	43.4	10.8	7.5
9. Upper Pines..........	7.1	4.3	36.3	30.5	48.5	43.1	9.5	7.5
5. Jack pine............	14.7	6.1	50.9	34.9	60.4	42.7	13.6	7.5
3. Black-white oak......	6.4	4.7	33.1	30.1	45.2	42.7	8.4	7.5
Maple-beech (Kalamazoo)	......	......	62.1	33.4	62.7	45.7	14.5	8.5

The soil is often so baked that it is grayish and "dead" to a depth of 4 or 5 cm. These oft repeated fires must have had marked influence upon growth increment of the facies, as well as largely determining the presence or absence and nature of the shrubby, herbaceous, and ground layers. The WC (column 4) exhibits in another way the same regressive influence due to humus destruction, producing a soil condition which must act selectively upon the various invading propagules. The uniform WHC and WC at 25 cm. in the Big Pines, as well as in the jack pines and oak associations, are very significant and form the evidence for the conclusion advanced in the former paper that the soil conditions reveal no differences of causal magnitude, and are thus clearly inadequate to explain present forest distribution, or to give any indication of a causal successional factor.

Fig. 5 is an attempt to exhibit to scale the soil-water relations in the Big Pines formation as they existed in August 1918. That the data may be comparable they are all computed on the basis of dry weight. The critical factor is the growth-water, whose theoretical possible maximum would be the difference between the WC and the WHC, or 29 per cent. This of course would scarcely ever be realized under field conditions. Actually the growth-water is the difference between the TFC and the WC, which in August 1918 was only 1.5 per cent, a quantity dangerously near the zero point of available water.

Evaporation.—The evaporation data were obtained in the usual way, Livingston standardized 8 cm. atmometers being used. During the month 284 mm. of rain fell on seven days, 250 mm. of

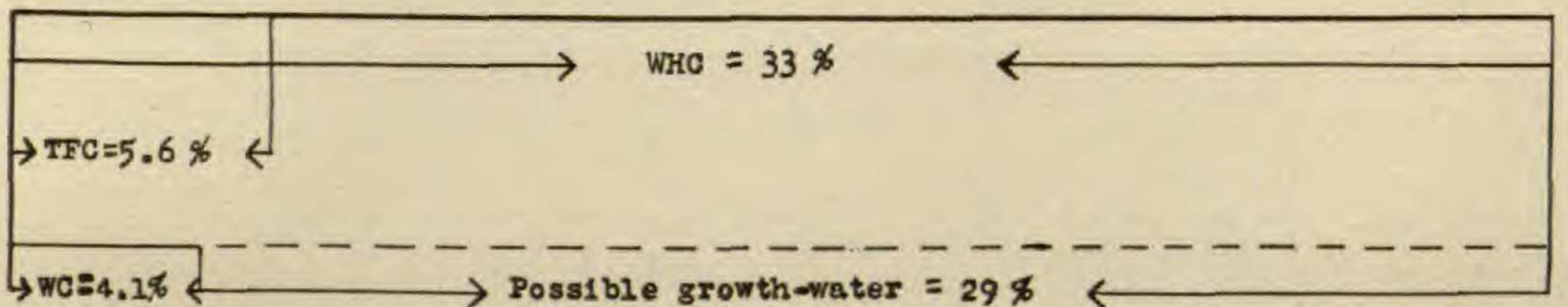

Fig. 5.—Soil-water relations (shown to scale): data on basis of dry weight.

this falling in twenty minutes. Rain correcting atmometers were not available, but it is thought that the use of these would not have given essentially different results. For five of the stations the records were taken daily; for the others every seven days. The 250 cc. reservoir bottles were all set slightly in the ground and stabilized with 12 inch length of $\frac{3}{16}$ inch mile steel to which they were bound by two bands of electric tape. Readings were made on an index mark on the neck of the bottle, and loss of water was supplied from a 50 cc. burette. Distilled water was used throughout. Stations were selected to represent various conditions of cover and canopy. The results are tabulated in table III.

The records in table III give evaporation rates only for the low herbaceous layer, and the average daily range from 8.3 to 18.6 cc. (124 per cent) is solely an expression of the degree of exposure, varying directly with the amount of insolation afforded by the herbaceous and shrubby layer. In connection with the record of station 1*B* (18.6 cc.) and of station 1 (19.5 cc.), a difference of only 0.9 cc. (4.3 per cent) would seem to indicate that the canopy exercises only a slight effect in reducing evaporation from the herbaceous layer. "On the basis of these results it would appear entirely unwarranted to assign evaporation as a causal factor in succession."

LIGHT.—The light determinations were made with a Waynne's Infallible Meter, as this was the only device available. All readings seek to represent the maximum shade conditions due to the canopy; all part shadows due to the trunks were avoided. The

TABLE III

AVERAGE DAILY EVAPORATION IN CC., AUGUST 4–31, 1918

Station	Association	Number of atmometers	Evaporation (cc.)	Average for Big Pines (cc.)
1*B*..........	Lower Pines, B.	1	18.6	....
1*C*..........	Lower Pines, C.	1	8.3	....
2...........	Lower Pines Terrace	2	10.4	....
6...........	Upper Pines, W. C.	2	12.5	....
7...........	Upper Pines, S.	2	8.7	....
8...........	Upper Pines, E. T.	2	14.7	....
9...........	Upper Pines, E. C.	2	16.8	12.79
5...........	Jack pine	2	12.7	....
3...........	Black-white oak	2	19.0	....
1...........	Open-standard	1	19.5	....
11...........	Garden, Kalamazoo	1	31.6	....

meter was placed upon the ground and the stopwatch held behind the back; both were released simultaneously. When the solio paper merged imperceptibly into the darker standard, the watch was stopped and the reading recorded. The results represent the averages of eight or ten readings (table IV). All light data are referred to full sunlight, which for convenience of comparison are reduced to the standard one, and all habitat records are correspondingly reduced to the same standard and expressed in the form of a ratio. Thus in station 1 the canopy reduces the sunlight to one-fifteenth its full intensity.

The range in the light ratios is largely a question of density of stand and so density of canopy. It is interesting to note that the yellow pine canopy with the same density of individuals produces a light screen of only about one-half the value of that of the white pine canopy. It would be of interest to know whether these shade differences are correlated with floristic or vegetational differences. This problem unfortunately escaped attention in the field.

Growth forms

Since the appearance of RAUNKIAER'S work in 1916, ecologists have viewed the influence of temperature factors from a radically new viewpoint. He points out that climatic conditions are reflected essentially in the biological nature of the vegetation, that is, in the nature and extent of the protection possessed by the perennating growth points during the winter or critical season. Upon the basis of this generalization he classifies vegetation into a series of

TABLE IV

LIGHT DETERMINATIONS, BIG PINES FORMATION

Station	Association	Ratio
1*B*	Lower Pines	1:15
2*A*	Lower Pines	1:12
7	Upper Pines	1:63
7	White pine canopy	1:57
7	Yellow pine canopy	1:30

life (or growth) forms. The following characterization of life forms and the abbreviations used are added for convenience of reference.[4]

Phanerophytes.—Woody plants of all types, both evergreen and deciduous, and exhibiting the least amount of protection from the cold, as showing the greatest amount of exposure. The group may be divided into *Megaphanerophytes* (MG), trees over 30 m.; *Mesophanerophytes* (MS), trees 8–30 m.; *Microphanerophytes* (MC), shrubs or trees 2–8 m.; *Nanophanerophytes* (N), shrubs under 2 m.

Chamaephytes (CH).—Perennial by virtue of the fact that the buds are just above the ground, or on the surface, and are thus often protected by the snow blanket.

Hemicryptophytes (H).—With dormant buds in the upper crust of the soil, the top of the plant dying down in winter.

[4] TAYLOR, N., The growth forms of the flora of New York and vicinity. Amer. Jour. Bot. 2:23–31. 1915.

Geophytes (G).—Perennial by bulbs, rhizomes, tubers, or by root buds.

Helophytes and *Hydrophytes* (HH).—The former has buds at the bottom of the water. Hydrophytes have perennating rhizomes or winter buds and are truly aquatic.

Therophytes (T).—Annuals.

On the basis of 400 species carefully selected from 1000 representative species, RAUNKIAER prepared what he calls a "normal spectrum," which shows the percentage distribution of these 400 species into the several life forms. This is now accepted as a basis of comparison.

The areas contiguous to the Big Pines have long been cleared, and are now covered with either grassy or shrubby plains or second growth oak associations. Considerable invasion has naturally occurred from these surrounding regions. Also repeated ground fires have run their course through both stands, although a part of the Lower Pines has been spared for several years. The north exposure of the immediate river banks furnishes many interesting isolated colonies of glacial relicts, but these, as well as the evident invasions, have been eliminated in the summary of species. An attempt has been made to include only those species which are evidently the natural components of the formation. Obviously this introduces the unchecked personal factor, and doubtless some errors of judgment have been made, but it is hoped not enough to essentially modify the results. As the study was made in August, doubtless some spring forms may also have been missed. On the basis of four separate lists, however, 100 species have been included (table V). In table VI the ecological spectrum of these 100 species is recorded. RAUNKIAER'S normal spectrum and TAYLOR'S (see footnote 4) spectrum of the northern elements of the flora within 100 miles of New York City are added for comparison. It should be noted further that only twenty-seven species have not been recorded outside of the Big Pines formation (table V). It is highly probable that careful search would further reduce this number.

A survey of the ecological spectrum of the Big Pines indicates that the mesophanerophytes determine the facies of the formation.

TABLE V

SPECIES OF THE BIG PINES FORMATION

Species	MS	MC	N	CH	H	G	T	Peculiar to form
Pteris aquilina*						×		
Pinus resinosa	×							
Pinus Strobus	×							
Agropyron tenerum						×		
Bromus ciliatus						×		
Bromus Kalmii						×		
Calamagrostis canadensis						×		×
Danthonia spicata						×		
Deschampsia flexuosa						×		
Koeleria cristata						×		
Melica striata						×		×
Muhlenbergia racemosa						×		
Oryzopsis pungens						×		
Panicum latifolium						×		
Poa triflora						×		×
Maianthemum canadense						×		
Polygonatum biflorum						×		
Smilacina racemosa						×		
Smilax hispida			×					
Cypripedium acaule						×		
Cypripedium hirsutum						×		×
Epipactis pubescens						×		×
Salix humilis			×					
Myrica asplenifolia			×					
Quercus alba	×							
Quercus rubra	×							
Actaea alba					×			×
Aquilegia canadensis					×			
Hepatica triloba				×				×
Arabis brachycarpa							×	
Ribes Cynosbati			×					×
Hamamelis virginiana		×						
Amelanchier canadensis		×						
Amelanchier oblongifolia		×						
Amelanchier spicata		×						×
Crataegus no. 1		×						
Crataegus no. 2		×						
Crataegus no. 3		×						
Fragaria virginiana				×				
Potentilla canadensis					×			
Prunus americana		×						
Prunus serotina	×							
Prunus virginiana		×						
Rosa humilis			×					
Rubus allegheniensis			×					
Rubus Idaeus			×					
Rubus triflorus			×					
Lespedeza procumbens							×	×
Xanthoxylum americanum			×					×
Polygala paucifolia						×		×
Acer rubrum	×							

* The nomenclature and sequence of the seventh edition of GRAY'S *Manual* have been followed. Specimens are preserved in the author's private herbarium.

TABLE V—*Continued*

Species	MS	MC	N	CH	H	G	T	Peculiar to form
Acer saccharum	×							×
Ceanothus americanus			×					
Viola arenaria						×		
Viola pubescens						×		×
Viola scabriuscula						×		
Aralia nudicaulis						×		×
Sanicula gregaria					×			×
Cornus circinata		×						×
Cornus paniculata		×						
Arctostaphylos Uva-ursi				×				
Chimaphila umbellata				×				
Epigaea repens				×				
Gaultheria procumbens					×			
Gaylussacia baccata			×					
Pyrola americana						×		
Pyrola secunda						×		
Vaccinium pennsylvanicum			×					
Trientalis americana					×			
Asclepias purpurascens						×		×
Monarda mollis					×			
Prunella vulgaris					×			
Satureja vulgaris				×				
Melampyrum lineare					×			
Pedicularis canadensis				×				
Galium pilosum					×			
Mitchella repens				×				×
Diervilla Lonicera			×					
Lonicera canadensis			×					×
Lonicera glaucescens			×					×
Sambucus racemosa			×					×
Triosteum aurantiacum					×			×
Viburnum acerifolium			×					×
Viburnum pubescens			×					×
Campanula rotundifolia				×				
Antennaria neodioica				×				
Antennaria Parlinii				×				
Antennaria plantaginifolia				×				
Aster laevis					×			
Aster Lindleyanus					×			
Aster macrophyllus					×			×
Helianthus mollis					×			
Hieracium canadense					×			
Hieracium longipilum					×			
Hieracium venosum					×			
Prenanthes trifoliolata					×			
Solidago caesia					×			
Solidago hispida					×			
Solidago rugosa					×			×
Solidago serotina					×			
Total: 100 species	7	11	18	11	24	27	2	27

It has been noted that the influence of oft repeated fires regulates the "presence or absence and nature of the shrubby and herbaceous layers." The large percentage of hemicryptophytes and geophytes in a forest formation are thought to be in large part an expression of this influence.

Valences

The biological spectrum furnishes one of the essentials in the ecological characterization of a formation. The method of valences also offers an objective means of presenting an equally important picture, that of the numerical abundance of the various floristic elements of the formation. It is the frequency percentage of the various elements which determines the aspect of the formation or its physiognomic character.

TABLE VI

PERCENTAGES OF GROWTH FORMS IN BIOLOGICAL SPECTRA

Type of growth form	MG	MS	MC	N	CH	H	G	HH	T
Big Pines........	0	7	11	18	11	24	27	0	2
Normal spectrum.	7		17	20	9	27	3	1	13
New York City...	0	1.31	3.94	8.55	8.55	26.31	24.34	23	3.94

Various methods have been employed since the introduction of the quadrat method in such statistical investigation. The method used in this study in an adaptation of that used by RAUNKIAER.[5] As only the facies was considered, it was possible to devise a rapid method of record. A rope 5 m. long held in the hand of an assistant formed the radius of a circle whose species were recorded as the investigator moved the radius through 360°. The center of the next area was obtained by swinging the radius through 180°, and with this as a fixed point the assistant then took his stand 5 m. farther on in the same axis. Thus areas are tangent to each other. In this way a transect of 200 m. was run. The valence records are thus based upon twenty such areas (table VII).

[5] For accounts of RAUNKIAER'S work see: SMITH, W. G., RAUNKIAER'S life forms, and statistical methods. Jour. Ecol. **1**:16–26. 1913; and FULLER, G. D., and BAKKE, A. L., RAUNKIAER'S "life forms," "leaf classes," and statistical methods. Plant World **21**:25–37. 1918.

The valence table shows that the yellow pine is slightly the dominant species in the Upper Pines. In the Lower Pines the reverse is true. It will be noted that this is due to the grouping of individuals of a species in certain parts of the stand, as is shown by transects IV and V. Similar grouping of the white pine is shown in transects I and II, while transect III shows an almost equal abundance of the two dominant species. These facts of abundance are not correlated with any soil differences as far as could be determined. It probably represents the influence of

TABLE VII

VALENCE OF FACIES IN FREQUENCY PERCENTAGE, UPPER PINES

Species	Transect no.					Total	Ratio
	I	II	III	IV	V		
Yellow pine	25	27	50	72	54	228	100
White pine	45	49	53	26	37	210	92
White oak	6	15	4	5	4	34	15
Red oak	0	1	0	0	0	1	0.4
Red maple	0	0	1	0	1	2	0.8
Total	76	92	108	103	96	465	....

persistent seed trees of the original stand which predominantly determined the nature of the succession within their respective areas.

The red and white oaks are rather constant members of the formation, the white oak always predominating. While they do not influence the physiognomy of the facies, yet in case of cutting or burning, the white oak is the persistent species and largely determines the nature of the reforestation, giving rise to the oak or mixed oak formation in which the red oak fails to reappear, being replaced by the black oak and in some cases by the additional invasion of the jack pine, neither of which, so far as observed, is ever found in the Big Pines formation. The red maple represents sporadic invasion from the not far distant margin or floodplain of the Little Manistee River. It was not recorded from the upland portions of the formation.

Age distribution of facies

The ecological spectrum (table VI) and valences (table VII) convey a very definite concept of the Big Pines formation. Nevertheless the picture is incomplete. It is to supply this deficiency in the visualization of the formation that the following method of analysis has been devised. It is essential that the age of the facies and the relative abundance of the individuals of each age be known, for therein is recorded not only the present status, but much of the

TABLE VIII

Age distribution of facies, Upper Pines, stations 6 and 7

Circumference classes in inches	10–15	16–20	21–25	26–30	31–35	36–40	41–45	46–50	51–55	56–60	61–65	66–70
Pinus resinosa	4	6	7	5	8	6	11	6	6	....	....	....
Pinus Strobus	2	7	8	8	3	6	6	6	7	2	....	1
Quercus alba	....	....	3	3	....	1	....	2	1	....	....	1
Quercus rubra	....	....	....	....	....	....	....	2	....	....	1	....
Acer rubrum	....	....	....	....	1	....	....	....	....	....	....	....

Circumference classes in inches	71–75	76–80	81–85	86–90	91–95	96–100	101–105	106–110	111–115	116–120	Total	Ratio
Pinus resinosa	1	1	2	....	....	....	....	....	....	....	63	100
Pinus Strobus	....	....	....	....	1	1	....	....	....	1	59	92.6
Quercus alba	....	....	....	....	....	....	....	....	....	....	11	17.2
Quercus rubra	....	....	....	....	....	....	....	....	....	....	3	4.7
Acer rubrum	....	....	....	....	....	....	....	....	....	....	1	1.5

past history, as well as the future ecological tendencies of the formation.

The data were obtained by running transects through several portions of the formation, measuring the circumference (BH) of the trees as met. Numerous cores were taken with an increment borer in order to establish an increment factor which could be used to convert the circumferences into age equivalents. This, however, gave no ratio entirely satisfactory for all sizes, probably due to too few samplings. It is believed, however, that the circumference data reveal the relative age distribution, although actual age determinations are greatly to be preferred. Several transects gave essentially identical results. The record of one of these transects, run in a portion of the formation where the shrubby layer was entirely lacking, is shown in table VIII.

Fig. 6 reveals the facts in an even more striking way. Before considering this graph of the age distribution, it should be stated that the five inch circumference classes are arbitrarily chosen. Each class represents approximately fifteen years. If actual age determinations were at hand, it would be desirable to use a one year class, thus more exactly recording the facts. It is thus

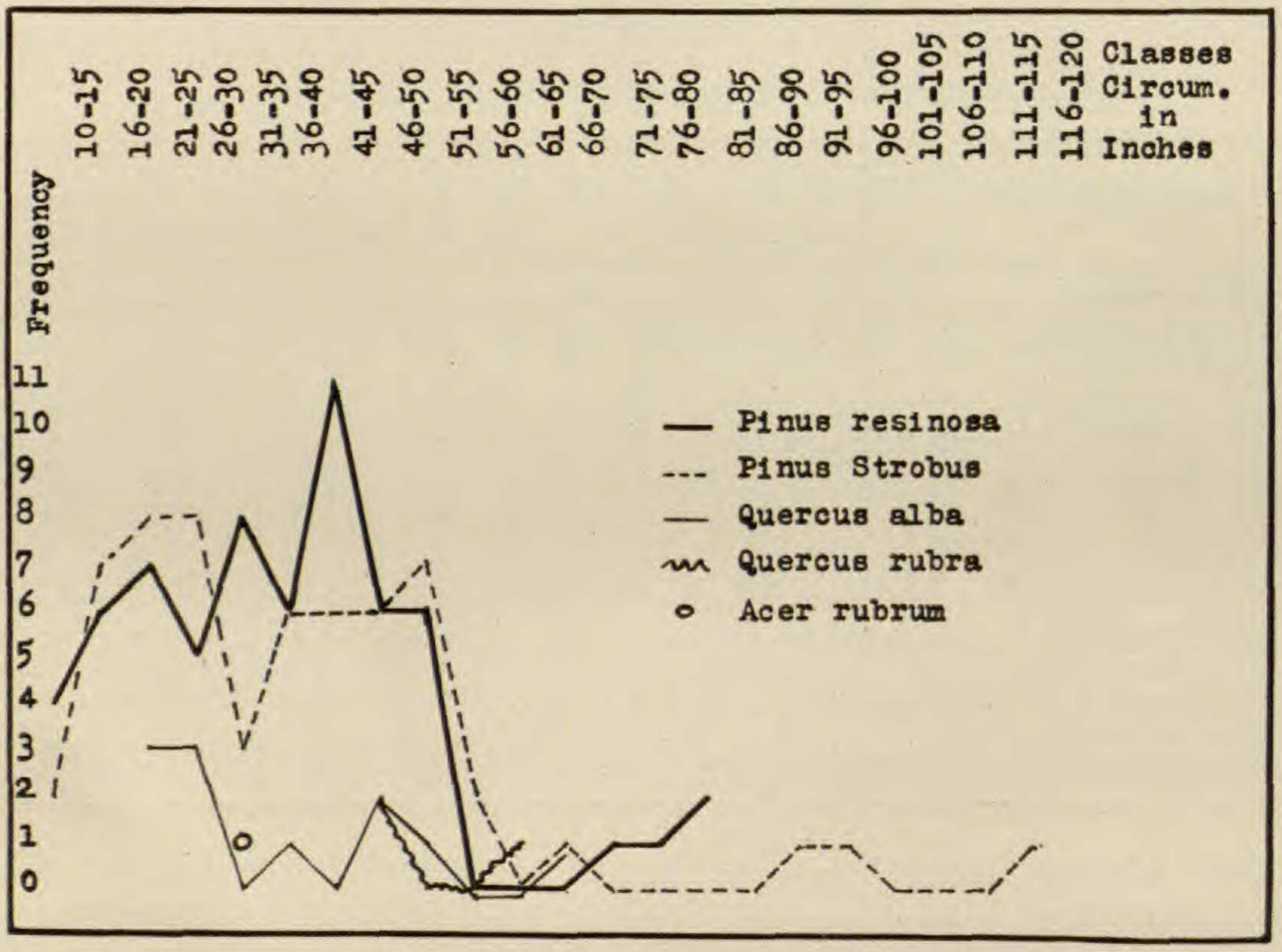

FIG. 6.—Age distribution of facies, Upper Pines, stations 6 and 7.

realized that the conclusions drawn from the graph are perhaps more valuable as a suggestion of a valid method of analysis than as a scientific representation of the actual conditions. It will be noted that the ratios of the three principal species of the facies (table VIII) are in almost perfect agreement with the ratios of frequency percentages as shown in table VII. It would appear that the transect analyzed is fairly representative of the formation.

Fig. 6 shows that the great mass of the individuals of the yellow pine lie between circumferences of 10 to 55 inches, which represents an approximate age range of 30–175 years. There are a few isolated individuals whose circumferences (75–85 inches) indicate an age range of 240–275 years. The graph shows three fairly well marked modal points which are thought to represent periods of more abundant seeding or ecesis. With actual age data these periods could be accurately indicated as to years.

The white pine shows essentially the same range in age, 30–190 years, with two modal points less clearly established. Taking both stands into consideration, there are a few isolated ancient trees of white pine not included in the transect, whose circumferences measure 100, 115, 134, and 146 inches, and whose ages range from 350 to 450 years.

The total absence of seedling and sapling pines in this transect is probably due to the influence of shade and fires, for in certain open stations protected from fires for a period of years germination of both species appears to be common and reforestation is in process.

Consideration has already been given to the white oak, red oak, and red maple in a previous section.

On the basis of the preceding data one may venture to reconstruct somewhat the history of the formation. The original stand of the Big Pines would appear to extend back some 400 or 450 or more years, and doubtless the formation had then been self-perpetuating for centuries. The break in age between these persisting patriarchs and the present stand, whose mass falls under 200 years of age, is very striking, although it is bridged somewhat by a broken series of isolated trees. What is the explanation of this break in history? The date of the original logging of this region would not appear to account for this hiatus. It would rather seem that there had been an almost entire destruction of this formation some 200 years ago, possibly through fire of lightning origin, which then became reestablished through a few isolated individuals of various ages escaping the devastation. The well distributed range of ages down to 30 years would apparently indicate that the formation has been and is under natural conditions permanently self-perpetuating. It represents an ecological climax (eschatophytic) formation.

Western State Normal College
Kalamazoo, Mich.